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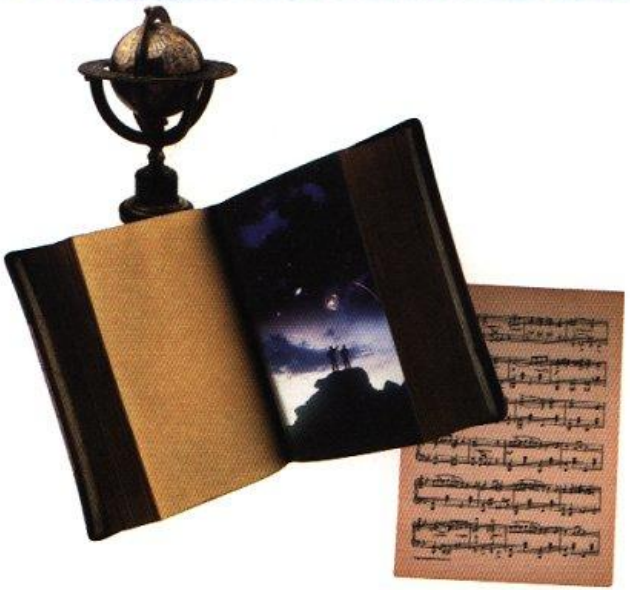

Biological Anthropology: An Evolutionary Perspective

Part I

Lecture 1: What is Biological Anthropology?
Lecture 2: How Evolution Works
Lecture 3: The Debate Over Evolution
Lecture 4: Matter Arising—New Species
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Biological Anthropology: An Evolutionary Perspective, Part I

Professor Barbara J. King

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Biological Anthropology: An Evolutionary Perspective

Professor Barbara J. King
The College of William and Mary

Part I

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Acknowledgement:

Footage of a rhesus monkey on Cayo Santiago provided by Christy Hoffman.

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Biological Anthropology: An Evolutionary Perspective

Scope:

These twenty-four lectures present detailed, up-to-date material about all aspects of the evolution of humanity. Aimed at those who are curious about our origins as a species, this course covers the wide range of topics in the discipline of biological anthropology. Biological anthropology takes as its goal a comprehensive exploration of the forces of both biology and culture that shaped human prehistory and continue to shape our lives today.

Following an introductory explanation of the various scientific approaches that together make up the field of biological anthropology, the initial lectures focus on evolution and its mechanisms. Important concepts, such as Darwin's principle of natural selection, are defined clearly, with real-life examples, and their significance is explained. What emerges from this section of the course is an understanding of why evolution and religious faith never need be opposed, whereas evolution and the theory of creationism are in direct conflict (with creationism rejected by scientists).

Applying these concepts to evolutionary history, Lectures Four through Eight explore the origins and behavior of the nonhuman primates. As primates ourselves, we humans share a 65-million-year evolutionary history with prosimians, monkeys, and apes. These lectures concentrate on primate behavior, showing how our own cognition, language, and kinship bonds developed out of the abilities present in these primate relatives. Particular emphasis is put on the great apes, such as chimpanzees, those animals closer to us genetically and behaviorally than any other.

The hominids, our extinct ancestors that walked upright, evolved from a common ancestor with the great apes nearly 7 million years ago. The anatomy and behavior of these species, ranging from the famous "Lucy," to the less well-known but equally important "Nariokotome Boy," to the cave-dwelling Neandertals, are profiled in Lectures Nine through Fifteen. These lectures highlight ways in which biology and culture intersect to allow for milestones to be reached in human prehistory.

Examples include the enlarged brain that allowed stone tools to be manufactured for the first time by hominids at 2.5 million years ago and the increasing cognitive skills and emotional ties that together led to deliberate burial of the dead by Neandertals at about 60,000 years ago. Two lectures deal with issues related to gender in prehistory, asking what we can know about the relative roles of females and males in hominid societies.

Lectures Sixteen through Eighteen are devoted to the origins of modern human anatomy, behavior, and language. Biological anthropologists have identified

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what they believe to be the oldest modern-human remains at about 125,000 years ago. For reasons made clear, it is unlikely that these earliest *Homo sapiens* could have evolved from Neandertals. From which hominids, then, did they arise? Was Africa the center of modern human origins, as it had been the center for early hominid evolution? We consider two competing models in evaluating these questions. One model points to Africa as the sole home of our species, whereas the other posits simultaneous evolution in Africa, Asia, and Europe.

Even more debated are the origins of modern human behavior and language. New evidence points to significant shifts in biological anthropologists' understanding of each of these topics. Sites in Africa tell us that symbolism, art, and finely crafted tools may not have first appeared at 35,000 years ago in Europe as long thought; evidence for a long evolutionary history for language is mounting as well.

The final five lectures consider modern human life in evolutionary perspective. A near-consensus conclusion in biological anthropology, that the practice of grouping humans into "races" based on supposedly genetic traits is invalid scientifically, forms the heart of Lecture Nineteen. Subsequent lectures explore ways in which evolution has tailored human anatomy and behavior, even today, to specific environmental pressures.

Also considered at length are fascinating new suggestions that modern health problems and aspects of modern health psychology have arisen as a direct result of conditions in human prehistory—conditions to which we were once adapted but no longer are. Pregnancy sickness and human mate choice are two case studies in this section.

The course concludes with a look at twenty-first century "gene discourse," in which undue power is given to genes and genetic research as panaceas for the future. An evolutionary perspective yields an understanding that the kinship we humans feel with other primate species (both living and extinct), as well as the tools we collectively have at our disposal for solving conflicts and other problems, are based not on genetics. Rather, they stem from a dynamic interplay of biological and cultural factors at work in our long evolutionary history.

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Lecture One

What is Biological Anthropology?

Scope: Many disciplines, ranging from psychology to sociology to history, take the study of human behavior as their central focus. Changes in behavioral patterns over time may be an explicit emphasis in some of these disciplines. Only in anthropology, and most especially in the subfield of biological anthropology, however, is the study of humans approached within an evolutionary framework.

This initial lecture sets the stage for our course in two major ways. We first explore the range of topics studied by biological anthropologists. Among them, we will emphasize the process of evolution; the anatomical and behavioral evolution of the primates, the larger taxonomic grouping to which humans belong (and that includes human ancestors); variation seen in modern human populations today, including the variation studied by forensic anthropologists; and the degree to which our current behavioral patterns reflect our evolutionary history.

Second, we tackle head on a question undergraduates sometimes pose: "What is biological anthropology good for? How can it help me in my own life?" An evolutionary perspective on human behavior results in more than just knowledge about dates and sites—when and where specific evolutionary milestones likely occurred. Rather, it is also a window on the past and future of our species. An entirely new way of thinking comes into focus when we consider the human species within an evolutionary perspective.

Outline

I. The discipline of anthropology is unlike other social sciences in its breadth of study generally and its use of the evolutionary perspective specifically.
   - **A.** Anthropologists are well known for studying behavioral variation in societies around the world, an endeavor that has become increasingly more appreciated as the world's cultures become increasingly interconnected.
   - **B.** One subset of anthropologists, the biological anthropologists, extends this cross-cultural view by adding time depth. They explore the origins of humanity well before the time period of written records and the modern outcomes of our long evolutionary history.

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II. Biological anthropologists approach their subject matter from a variety of angles within the evolutionary perspective.

A. Anthropological geneticists and evolutionary theorists help clarify how processes of evolution once occurred and may now affect modern human populations.

B. Primatologists study aspects—evolution, anatomy, and behavior—of the hundreds of primates living today. The primates are we humans and our closest living relatives, the prosimians, monkeys, and apes.

C. Paleoanthropologists study the anatomy or behavior of the hominids, the now-extinct fossil forms that existed in the evolutionary line that gave rise to modern humans.

D. Biological anthropologists interested in modern human variation conduct research to discover how and why various living populations are similar and different genetically, anatomically, and behaviorally.

E. Forensic anthropologists work to identify human remains in various contexts, often with application in legal matters.

F. A final group of biological anthropologists works to assess the degree to which modern human groups are "adapted to the past," that is, are directly affected by the conditions under which our species evolved in the past.

G. Biological anthropologists are likely to work with scientists from other closely related disciplines.

III. Biological anthropologists see their discipline as having genuine practical use in the modern world.

A. Although names, dates, and site locations are important to the study of biological anthropology and indeed to this course, they are not at its heart.

B. The evolutionary perspective asks its students—novices and old hands alike—to embrace a shift in perspective.

1. As humans, it may be more meaningful to think of ourselves as primates rather than as a unique species. We are not the "end product" of millions of years of evolution but one well-adapted species in an array of well-adapted species living on Earth.
2. However, our achievements as humans have come about because of a unique mix of biological and cultural processes.

C. We may gain insight into some very down-to-earth issues by adopting the evolutionary view of human history.

1. Why are humans prone to choking while we eat and to lower back pain as we age? Our anatomical evolution gives us clues.
2. Why do children learn complex languages so effortlessly, without being directly taught? Our social evolution helps explain this mystery.

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3. How can we bring to bear good scientific logic in dealing with contentious issues, for example, whether perceived racial differences are rooted in biology? Understanding the facts of hominid evolution together with those of modern population variation lets us proceed based on knowledge rather than on assumption.

D. In sum, the evolutionary perspective is a way of thinking about humans' place in the world and how we can improve our lives today.

Essential Reading:

Jurmain et al., *Introduction to Physical Anthropology*, chapter 1.

Questions to Consider:

1. Have you already encountered the subject matter of biological anthropology before embarking on this course, perhaps through reading or musing about the human evolutionary past?
2. Do you believe it is important for biological anthropology to have an applied, practical aspect, as well as a purely scholarly and intellectual function?

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Lecture Two

How Evolution Works

Scope: One single concept is the best starting point for our exploration of humans in evolutionary perspective. Like all other life on earth, humans have evolved. But what, exactly, does this mean? By establishing a common set of terms and definitions, we will set about answering this question.

Evolution can be defined as a change in the genetic structure of a population. To grasp this definition, we need to understand something about genes, populations, and species. From there, we can proceed to discuss the mechanisms, or *forces*, behind evolutionary change.

Most important of the evolutionary forces is natural selection, first described by Charles Darwin in the nineteenth century. The main idea behind natural selection is that in any population, some individuals will be better adapted to their local environment than others. As a result, these individuals will have greater success than others in reproducing.

A good way to approach the study of evolution is to consider popular myths about it, then learn why these myths should be rejected. Because evolution is "only a theory," doesn't that imply uncertainty about it on the part of scientists? Can't the entire process be explained by the phrase "survival of the fittest?" Hasn't evolution in fact come to a halt in today's world? The answer to all three questions is a resounding no, and we will work to understand why.

Outline

I. The single most critical process in this course is evolution, defined as a change in the genetic structure of a population.

- **A.** All humans belong to the same species, but many human populations exist. No meaningful category exists in our species between the species level and the population level.
- **B.** Most mating takes place within, rather than between, animal populations. This is true even though populations are "open" rather than "closed"; that is, some individuals will enter or leave a single population in any given time period.
- **C.** As a rule, members of a population share a common gene pool. When this gene pool undergoes systematic change over time, evolution is said to have occurred.
- **D.** The key changes that occur evolutionarily are found, then, at the level of the gene pool.

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1. The genes that make up these gene pools are frequently misunderstood. Genes rarely have the power to *determine* an individual's anatomy, physiology, or behavior. Genes interact with the environment at all stages of their functioning.
2. Genes are made up of component parts of DNA and, as such, do greatly *influence* various aspects of an individual's life.

II. Four mechanisms of change can affect the genetic structure of gene pools and, thus, contribute to evolution.

- **A.** Natural selection, the primary evolutionary mechanism, is a cornerstone concept of this course. It is closely related to the idea of differential reproductive success.
  1. *Differential reproductive success* means that some individuals in a population will produce more healthy offspring than will others.
  2. Because of differential reproductive success, the relative frequency of traits in a gene pool may shift over time. Traits that increase or are maintained within a population are, thus, *naturally selected.*
  3. Charles Darwin came to understand the action of natural selection during and after his famous travels as a naturalist. His major contribution was to offer the scientific world, for the first time, a plausible mechanism of evolutionary change.
- **B.** *Mutation* refers to a change in the structure of DNA itself and produces raw material on which natural selection may act.
- **C.** *Gene flow* refers to the exchange of genes between populations.
- **D.** *Genetic drift*, a mechanism at work in small populations, refers to changes in a gene pool's makeup that occur because of random events.

III. Some widely cited myths may cloud our understanding of the importance of evolution and how it works to produce change over time.

- **A.** Isn't evolution just a theory? That is, isn't it just a good educated guess by scientists at how things work?
  1. In science, the word *theory* has a very specific meaning. It refers to a set of principles that has been supported by a great deal of observation and testing.
  2. For biological anthropologists, there is no doubt: humans evolved. The details of exactly how the four mechanisms interacted to produce evolutionary change may not always be known, but the process itself is not in doubt.
- **B.** Isn't "survival of the fittest" a good enough summary of how evolution works?
  1. Reproduction is the key to understanding evolution, not survival.
  2. Just as with the term *theory*, the term *fittest* has a precise meaning in evolutionary science. To be *fit* means to be able to outcompete reproductively other members of one's gene pool.

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C. Hasn't biological evolution been far outstripped, at least for humans, by cultural evolution?
   1. Biological evolution and cultural evolution interact. Each process affects the other.
   2. Humans are still subject to natural selection in many ways in today's world.

D. As we will see in the next lecture, the United States, among many Western cultures, is particularly prone to confuse myth with scientific fact when considering evolution.

Essential Reading:

Jurmain et al., *Introduction to Physical Anthropology*, chapter 2 and pp. 89–104 in chapter 4.

Gould, *The Structure of Evolutionary Theory*, especially chapter 2.

Questions to Consider:

1. Why is it crucial to recognize the importance of reproduction over survival in the process of evolution?
2. If you heard a claim that the scientific understanding of evolution, especially human evolution, is "only a theory," how would you respond?

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Lecture Three

The Debate Over Evolution

Scope: Nearly one-half of Americans, according to a recent poll, reject the idea that humans evolved from other animals over millions of years. The comparable percent in European countries is substantially lower. Why are Americans so skeptical about human evolution? Some of that skepticism may be predicated by confusion about evolution.

Biological anthropologists, along with scientists in numerous other disciplines, have a special responsibility when informing the public about evolution, particularly about the relationship among evolution, religion, and creationism.

Deeply religious feelings may be compatible with acceptance of evolution, including human evolution. As the noted scientist Stephen Jay Gould recognized, many prominent evolutionary scientists are religious and many religious leaders accept the fact of evolution.

Incompatible with acceptance of evolution, however, is belief in special creation, also called *scientific creationism*. We will uncover this incompatibility by contrasting the claims of creationists and those who espouse a newer doctrine, termed *intelligent design*, with the claims of evolutionary theory.

Outline

I. Many Americans are skeptics when it comes to accepting the fact of evolution, including human evolution.
   A. A substantial number of people in the United States embrace the idea of humans as "specially created" by a supernatural force within the last 10,000 years.
   B. Legal challenges to the teaching of evolution in the public school system continue to occur, more than 75 years after the famous Scopes Monkey Trial in the American South.
   C. A feeling that it is necessary to choose between one's religious beliefs and an acceptance of evolution may partly explain why more Americans are "evolution skeptics" than are Western Europeans.

II. Science, including evolutionary theory, and religion are wholly compatible; no one must choose between them, although, of course, a choice may be made.
   A. As Stephen Jay Gould has eloquently written, science and religion represent two very different systems of knowledge; it is their profound differences that allow them to coexist.

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B. Science is fundamentally predicated on observation, evidence, and hypothesis testing; without these, science has no meaning.

C. Religion is based on faith; in this realm, observation, evidence, and hypothesis testing have no meaning.

III. Science, including evolutionary theory, and scientific creationism are totally incompatible; here one must make a choice.

A. In the strictest form of scientific creationism, four tenets are key:
   1. The Earth is young, not ancient.
   2. Humans were specially created by a supernatural being.
   3. The claims of evolutionary scientists are inaccurate; supposedly ancient human fossils, for instance, are misdated or misinterpreted.
   4. As a science, scientific creationism deserves equal time with evolution in public schools.

B. Evolutionary scientists reject these tenets point by point, emphasizing particularly that "scientific creationism" is in fact a misnomer.
   1. The core ideas of scientific creationism cannot be tested according to the scientific method.
   2. Scientific creationism, which is thus not a science at all, ignores or distorts well-established information and should not be taught as science in schools.

IV. Intelligent design differs from scientific creationism, yet is equally incompatible with evolutionary theory and equally rejected by almost all evolutionary scientists, including biological anthropologists.

A. Unlike scientific creationists, intelligent design advocates accept that the Earth is ancient and that species may change somewhat over time. Their ideas are, therefore, superficially more like those in evolutionary science than those in scientific creationism.

B. Intelligent design adherents, however, challenge Darwinian theory through the concept of *irreducible complexity*.
   1. According to this idea, some systems are so complex and contain so many interrelated functioning parts, that they could have emerged only by design. They could not have come about by evolutionary change through small successive modifications over time.
   2. The complex mammalian eye, say those who espouse intelligent design, is a good example of a phenomenon that is irreducibly complex.

C. Evolutionary scientists, including biological anthropologists, counter by explaining that we can indeed use evolutionary theory to trace the emergence of the complex mammalian eye.
   1. The form of the eye can be charted, from simple to more complex, across evolutionary time.

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   2. Evolutionary change need not always proceed through small successive modifications, however; *punctuated equilibrium* may also occur. As devised by Stephen Jay Gould and Niles Eldredge, punctuated equilibrium is described as evolutionary stasis broken up by rapid evolutionary leaps.

D. Evolutionary science and intelligent design ideas are fundamentally opposed in how they view the origins of human life.
   1. Using an argument parallel to the one about the complex eye, intelligent design advocates say that humans are complex and must have arisen by design.
   2. Scientists again counter with evidence from the scientific record, noting that the mechanisms of evolution can indeed account for human evolution.

E. We conclude this lecture by affirming that biological anthropologists accept the theory of evolution as a fundamental part of their intellectual toolkit.

Essential Reading:

Gould, *The Structure of Evolutionary Theory*, especially chapter 9.

Natural History, April 2002 issue (special report on intelligent design ideas plus Carl Zimmer's column "The Evolutionary Front"), and/or *Scientific American*, July 2002 issue (article by Rennie called "15 Answers to Creationist Nonsense").

Supplementary Reading:

Behe, *Darwin's Black Box: The Biochemical Challenge to Evolution* (for those who wish to read about intelligent design doctrine by one of its proponents).

Questions to Consider:

1. What questions, if any, has this lecture raised in your mind about the relationship of science and religion?
2. Why do you think the intelligent design doctrine is currently getting so much more attention than is scientific creationism?

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Lecture Four

Matter Arising—New Species

Scope: Let's move to another layer of detail now in our exploration of the evolutionary process. We have considered how changes may occur within a species over time, but how do new species appear to begin with? That is, how does *speciation* occur?

Reproductive isolation is the critical process by which speciation normally occurs. As populations become isolated from each other, they respond differently to slightly different natural selection pressures. Eventually, individuals from different populations can no longer interbreed successfully. A related process called *adaptive radiation* is particularly well understood by evolutionary biologists and will provide us with a classic case study.

For this case study, we turn again to Darwin; his understanding of speciation and adaptive radiation, developed while in the Galapagos Islands observing finches and other species, still instructs us today. Further, evolutionary biologists have recently published major work on the ongoing nature of evolution among the Galapagos finches, which reinforces much of what we have learned about natural selection, as well as about speciation.

How does speciation relate to human evolution, though? Let's take the long view and consider what has happened over the last 65 million years. Before that date, no primates yet existed in the world, though other mammals flourished. Adaptive radiations since that time have resulted in the diversity of primate species we see today—more than 200. What role did natural selection play in this process? This question is best answered by considering how primates differ from other mammals.

Outline

I. We have explored how natural selection and other evolutionary forces work on established populations. How can these forces, though, account for the diversity of life on Earth? How do new species arise in the first place?

- **A.** *Speciation* is the term for the process by which new species are formed from earlier, existing ones.
- **B.** A key requirement for speciation is reproductive isolation. Two populations must be effectively separated from each other, disallowing mating between them.
  1. Reproductive isolation may occur because two populations become separated by some geographic barrier.
  2. Alternatively, two populations may become isolated because of behavioral barriers.
  3. With either type of isolation, slightly different selection pressures begin to operate on the two populations. Slowly, differences between them mount.
  4. Speciation is complete when individuals from the original two populations could no longer interbreed and produce fertile offspring if brought back together.

II. When a variety of new forms—including new related species—adapts to and fills a variety of ecological niches, we say that *adaptive radiation* has occurred.

- **A.** Adaptive radiation has occurred multiple times in evolutionary history.
- **B.** The principles of adaptive radiation are most clearly illustrated by Darwin's case study of the finches of the Galapagos Islands.
- **C.** Thirteen different varieties of Galapagos finches were noted by Darwin. These differed mostly in the shape and size of their beaks, one finch form for each island in the Galapagos chain.
- **D.** Darwin realized that these thirteen varieties had descended from one common ancestor. Each form adapted to local selection pressures during adaptive radiation.
- **E.** Biologists Peter and Rosemary Grant returned to study the Galapagos finches in the 1970s.
  1. The Grants' research confirmed many of Darwin's insights.
  2. The Grants showed specifically that recent, severe environmental changes caused new evolution in the Galapagos finch populations.

III. Adaptive radiations are also important in the evolution of the primates, the group that includes humans.

- **A.** Approximately 70 million years ago, no primate populations existed in the world.
- **B.** Perhaps about 65 million years ago, some ancestral rodent-like populations began to undergo new selection pressures. Through the process of speciation, primates began to appear.
- **C.** The original "push factor" in this series of speciation events is highly debated, but a likely candidate is the need to hunt tree-living, fast-moving insects for food.

IV. The nature of primate evolution can be best understood by exploring the new traits that emerged when primate species first originated. These traits still characterize the primates today.

- **A.** Five key traits distinguish the primates from other mammals.
  1. Grasping hands allow primates to hold branches, fur, and objects.
  2. Depth perception enables primates to judge distances accurately.

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3. A large, complex brain underwrites abilities for primates to learn about the world socially from their companions.
4. Single births typically occur, followed by a prolonged period of maternal dependency.
5. Primates are highly social mammals, characterized by intense social bonds.

B. With this pattern of traits as a fundamental adaptation, various species of primates adapted over time to local circumstances. Gradually, we ended up with the array of more than 200 primate species we see today.

Essential Reading:

Weiner, *The Beak of the Finch: A Story of Evolution in Our Time.*

Questions to Consider:

1. Why is it important to understand that evolution works at two levels—producing change within existing populations and creating new species?
2. In what ways can you recognize the five key primate traits at work in your own life?

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Lecture Five

Prosimians, Monkeys, and Apes

Scope: With this lecture, we shift our focus away from evolutionary theory to begin a detailed exploration of our closest living relatives, the primates. Having already learned what unites primates as a taxonomic group, we will now consider the major subgroups within nonhuman primates: prosimians, monkeys, and apes. These nonhuman primates are distributed across major regions of the world's tropics (and, in a few cases, outside the tropics).

Prosimians are nocturnal, often solitary creatures, with notable anatomical specializations compared to the other primates. The ring-tailed lemur of Africa and the slender loris of Asia, however, are examples of highly social prosimians. Primatologists are just beginning to appreciate the full complexity of these prosimians' social lives, as we will discover.

All the other nonhuman primates, besides prosimians, are anthropoids. As their name implies, these creatures, the monkeys and apes, are considerably more like humans than are the prosimians. We will compare and contrast the monkeys and apes to each other and make distinctions within each category, as well.

Although some scientists had studied both wild and captive anthropoids in the early decades of the twentieth century, the relevance of such work to American anthropology was clarified exponentially in 1951. In that year, Sherwood Washburn laid out a carefully conceived (now classic) plan for using anthropoid research to directly guide and aid our understanding of human evolution. Extending over the last half-century, Washburn's influence has greatly affected our conception of the relationship between anthropology and primate studies.

Outline

I. The nonhuman primates, united by the five major characteristics we learned in Lecture Four, are found mostly throughout the tropical and subtropical regions of the New World (southern Mexico, Central and South America) and the Old World (Africa and Asia).

II. Prosimians, found only in the Old World, are the first of three taxonomic divisions of the nonhuman primates.

A. Prosimians evolved first, before the other nonhuman primates.

B. As a group, prosimians have some anatomical specializations that are atypical for primates as a whole.

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1. Some prosimian features, particularly those relating to the sense organs, relate to these primates' nocturnal lifestyle.
2. Although prosimians do have the five primate characteristics, some are not as highly developed as among the anthropoids.

C. Often, prosimians are portrayed as the least complex primates in terms of social behavior and intelligence.

D. Detailed research suggests that this "least complex" generalization may be too hasty and superficial a conclusion.

1. The ring-tailed lemurs of Africa are day-living and group-living primates, with a behavioral hierarchy in which females outrank the males.
2. The nocturnal slow lorises of Asia, thought until quite recently to be relatively solitary, actually show social behaviors, such as play, grooming, and male parental care.

III. Anthropoids, the monkeys and apes, are day-living, group-adapted primates with more elaborated primate characteristics.

A. Monkeys are found in both the New World and the Old World. They are relatively small-bodied, with equal-length arms and legs for quadrupedal walking and a tail.

1. New World monkeys are arboreally adapted. They vary in size, social organization, and behavior. Marmosets and muriquis, both from Brazil, illustrate some of these differences.
2. Old World monkeys may be either arboreal or terrestrial. They, too, vary in size, social organization, and behavior. A comparison of different African baboon species can illustrate some of these differences.

B. Apes are found only in the Old World. They are typically larger bodied than monkeys, with longer arms than legs for swinging through the trees and no tail.

1. "Lesser" apes, such as gibbons, are small-bodied arboreal species from Asia. They typically live in mated pairs.
2. Great apes are larger-bodied species from either Asia or Africa. As humans' closest living relatives, great apes are important for biological anthropology.
   - **a.** Orangutans, the red apes of Asia, are arboreal and less social than the other great apes.
   - **b.** Gorillas, found in Africa, live in one-male or two-male social units.
   - **c.** Chimpanzees and bonobos, found in Africa, are closely related species that live in bisexual communities.

IV. The study of nonhuman primates, particularly the anthropoids and even more particularly the great apes, took on added focus and significance in the year 1951. This is when American anthropologist Sherwood Washburn developed his "new physical anthropology."

A. Washburn felt that physical, now called biological, anthropology, was too focused on static measurement and classification.

B. Washburn wished to focus instead on the dynamic processes of evolutionary change and how these affected primates. He envisioned a new interdisciplinary synthesis, centering on questions of evolutionary change.

C. A major method of the new physical anthropology involved comparing and contrasting the evolutionary adaptations of different primates. A wave of Washburn's students entered the field to study the adaptations of monkeys and apes. They compared and contrasted these primates' adaptations with those of humans and their direct ancestors.

D. Washburn's reformulation of biological anthropology was a turning point in the field. A key element of the discipline today continues to be comparative research, aiming to illuminate the study of human evolution and behavior. Primate studies are, thus, an integral part of anthropology.

Essential Reading:

Jurmain et al., *Introduction to Physical Anthropology*, chapter 5, pp. 106–132.

De Waal, *Tree of Origin*, chapter by Strier.

Questions to Consider:

1. Why might Washburn welcome the recent research showing that prosimians are not as behaviorally distinct from monkeys and apes as first thought?
2. Visit a zoo, if possible, whether in "real life" or virtually, on the Internet. Are you able to spot some obvious anatomical differences between monkeys and apes?

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Lecture Six

Monkey and Ape Social Behavior

Scope: Data on monkeys and apes suggest that their extensive sociality is founded on a base of strong social bonds, which in turn, is founded on kinship or close association. The existence of kinship networks means that relatives recognize, and act preferentially toward, one another. The *matrilines* (groups of related females) of rhesus monkeys and the *patrilines* (groups of related males) of chimpanzees provide excellent examples of such kinship networks.

Rhesus monkeys transported from their native Asia to the Puerto Rican island of Cayo Santiago have been studied for 50 years. Research has shown that dominance, or a system of relative ranking, is an organizing principle of the rhesus society. The divergent paths taken by males and females in this society are mirrored in the monkeys' behavior, starting at about 1 year of age.

Long-term studies of the chimpanzee, both at Gombe, Tanzania (East Africa), and Tai, Ivory Coast (West Africa), point up some fascinating contrasts with the lives of rhesus monkeys. First, chimpanzees live in patrilines. Male-male bonds (among kin and non-kin alike) underlie many complex chimpanzee behaviors, including cooperative hunting groups and defensive patrols. Juvenile chimpanzees develop much more slowly than do monkeys; they remain dependent on their mothers for much longer, but male and female lives do eventually begin to diverge.

The lives of Cayo Santiago rhesus monkeys and African chimpanzees can shed light on human behavior, just as Sherwood Washburn predicted more than 50 years ago. Through this kind of study, we can identify fundamental primate (including human) patterns.

Outline

I. In their social groups, individual monkeys and apes form strong social bonds with selected companions.

- **A.** Some of the strongest social bonds are based on recognizing and acting preferentially toward one's relatives.
- **B.** Other social bonds are predicated on close associations, or what some primatologists call "friendships" between nonrelated individuals.

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II. Some of the most well studied monkey species live socially in groups organized around *matrilines*, or groups of female relatives. Rhesus monkeys of Cayo Santiago, an island off Puerto Rico, have taught biological anthropologists much about matrilines.

- **A.** Rhesus monkeys, transported from Asia to Cayo Santiago for research purposes, live on their island in ways quite similar to their lifestyle in the wild. The matrilines form the core of each group.
- **B.** Dominance, or relative ranking of monkeys who compete for resources, is the organizing principle of Cayo Santiago rhesus monkey life.
  1. Groups are ranked in relation to one another.
  2. Within a group, matrilines are ranked in relation to one another.
  3. Within a matriline, the rule of "youngest sister ascendancy" applies: each mother favors her newest daughter.
- **C.** Male and female rhesus monkeys begin to socialize differently in their groups at around their first birthday. Matrilineal life and the rules of dominance affect males and females quite differently.

III. Chimpanzees, which are great apes rather than monkeys, live social lives that contrast in interesting ways with those of Cayo Santiago rhesus monkeys.

- **A.** Chimpanzees live in *patrilines* that form the core of each community.
- **B.** Dominance is important in chimpanzees' lives. The male dominance hierarchy is a focus of attention within the community, with a single "alpha" male at the top.
- **C.** Male-male bonds, whether within patrilines or outside of them, also form a focus of the chimpanzee community.
  1. Males work together to hunt and eat monkeys.
  2. Males cooperate to "go on patrol" and protect their community borders.
  3. Chimpanzee communities are vastly more male-oriented than are rhesus monkey groups.
- **D.** Ape youngsters develop much more slowly than do rhesus monkey infants; at 1 year of age, they are still infants. Male and female lives do gradually begin to diverge in chimpanzees, however.

IV. What can biological anthropologists learn about humans from the long-term data about behavior in rhesus monkeys and chimpanzees?

- **A.** Despite their many differences in social organization, these two species attest to the balance between cooperation and competition that characterizes group living in anthropoids.
- **B.** Just as Sherwood Washburn envisioned, this type of comparative research has been used to forge useful conclusions about primate evolution.

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1. A deep layer of primate social grouping and social bonding is present, despite variation in its form, across all primates.
2. The variation in social grouping and social bonding can be understood by looking at local conditions and selection pressures to which different species adapt.
3. Human evolution, too, proceeds according to adaptation to local conditions and selection pressures.

Essential Reading:

Jurmain et al., *Introduction to Physical Anthropology*, chapter 6.

De Waal, *Tree of Origin*, chapters by Pusey and de Waal.

Supplementary Reading:

Sapolsky, *A Primate's Memoirs*.

Questions to Consider:

1. Imagine how the concepts of *power* and *politics* might be applied to rhesus females and to chimpanzee males striving for high rank.
2. Can you think of reasons why dominance-related behaviors would be maintained by natural selection, even though some individuals will inevitably be low ranked?

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Lecture Seven

The Mind of the Great Ape

Scope: Although as we have seen, monkeys and apes may share fundamental primate characteristics, many scientists acknowledge a "watershed" in terms of cognitive abilities between them. Apes—in particular the great apes—seem capable of cognitive achievements not reached by monkeys. The ability to make and use tools is one example. In this lecture, though, we will concentrate on two other examples of great ape cognitive sophistication: theory of mind and use of complex nonvocal communication.

Having a *theory of mind* is defined as the ability to take into account the mental perspective of another individual. Humans do this without a second thought; daily, we size up what our family members and friends might know, think, or feel in a given situation. Great apes, far more than monkeys, seem to approximate this ability. Great apes appear to realize, for instance, when an associate, whether an infant or another adult, lacks knowledge in a certain situation, then act in ways to make up for that ignorance.

Further, some great apes spontaneously use complex gestures and gestural sequences. Others are able to perform in various language-like ways when exposed to human symbols. These enculturated great apes, raised in enriched environments, help guide anthropologists through aspects of the great ape mind. We will focus on the chimpanzee Ai, who resides in a research facility in Japan with her son Ayumo. The two participate in fascinating experiments that allow scientists to probe chimpanzees' cognitive abilities.

Outline

I. Apes, especially the four great apes, outshine monkeys and prosimians in terms of their cognitive abilities.
   - **A.** For some scientists, this statement is a firm conclusion. They point to studies of tool-use and tool-making as support for this claim. Chimpanzees and orangutans in the wild show the most elaborated technologies of any primates other than humans.
   - **B.** For other scientists, this statement is a hypothesis that needs further testing. They note that some wild monkeys, for example, capuchins, have been found recently to use tools in ways that rival what chimpanzees do and exceed what gorillas and bonobos do.

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II. *Theory of mind* is one area in which great apes seem clearly capable of higher cognition compared to other nonhuman primates.
   A. Having a theory of mind means that one individual can take into account another's mental state, that is, take into account what that second individual might know or believe about the world.
   B. A series of experiments, some formal and some informal, demonstrate that great apes behave as if they can figure out a companion's mental state.
      1. Chimpanzees will warn companions who lack knowledge of impending danger but refrain from warning companions who are already aware of the danger.
      2. Monkeys do not reliably distinguish between their companions' state of knowledge versus ignorance in the face of danger.
   C. Observations in the wild back up the claim for theory of mind, especially in chimpanzees.
      1. Chimpanzee mothers teach their offspring more often than do monkey mothers, thus giving evidence that mothers recognize their offspring's ignorance.
      2. In some situations, chimpanzees show empathy to others in ways that are consistent with theory of mind.

III. Complex communication is another context in which great apes amaze scientists, achieving heights not reached by any monkey.
   A. Vocal communication is not a good candidate for supporting the "ape watershed." That is, great ape vocal communication may differ little from that of other nonhuman primates.
   B. Gesturally, however, apes excel compared with monkeys.
      1. Great ape gesture may be both intentionally communicative and iconic, that is, indicative of specific actions that social companions should take.
      2. Some great apes "converse" using strings of gestures put together in meaningful sequences.
   C. Enculturated great apes, those raised in enriched captive environments, surprise scientists by mastering use of human symbol systems.
      1. The chimpanzee Ai, part of a Japanese research project, can solve problems and communicate with symbols on a computer.
      2. Ai's son Ayumo has, at a very young age, learned some knowledge of these symbol systems.
      3. Results from the Ai project dovetail nicely with results from other enculturated ape research in the United States, primarily the project involving the bonobos Kanzi and Panbanisha.

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IV. Profound implications for the study of human behavior emerge from consideration of the monkey-ape watershed.
   A. Part of the great ape adaptation is the ability to use higher cognition and sophisticated communication abilities in negotiating everyday life.
   B. Great apes represent a "baseline" from which to model the action that occurred during human evolution.

Essential Reading:

Jurmain et al., *Introduction to Physical Anthropology*, chapter 7.

I strongly recommend viewing a Web site about Ai. Go to a good search engine, such as www.google.com, and type in "Chimpanzee Ai's homepage."

Supplementary Reading:

Savage-Rumbaugh and Lewin, *Kanzi.*

Questions to Consider:

1. Can you recall a recent incident in which you used theory of mind to predict or understand a companion's actions? Can you recall an instance in which a young child could not, yet, take another's perspective?
2. To what use do you think the chimpanzee Ai's abilities, as seen in the research laboratory, might be put in her natural African habitat?

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Lecture Eight

Models for Human Ancestors?

Scope: Previous lectures have demonstrated that we humans inherit from other primates, especially the great apes, an evolutionary legacy based on strong social bonds and rudimentary abilities in technology, cognition, and language. But can data from great apes help us to model the evolution of the human species more directly?

Biological anthropologists use three types of models to elucidate how human behavior, including cognition and communication, may have evolved from a nonhuman primate foundation. Referential models claim that the behavior of one specific nonhuman primate is the single best referent for some human ancestor. One model suggests, for instance, that the evolution of human hunting can be illuminated by an analysis of chimpanzee hunting behavior.

Other anthropologists, preferring to broaden the source base, look not just at one nonhuman primate but at all four types of great apes. If some behavioral trait is found in all the great apes, then a claim for its appearance in early human evolution is strengthened. According to this approach, because hunting is so variably expressed among the different great apes, caution must be used in drawing conclusions about the evolution of hunting behavior in humans.

Finally, conceptual models may be used. Evolutionary processes, rather than specific primates, are the focus of conceptual models. Regarding hunting, a conceptual model would attempt to look at the natural selection pressures that seem to push nonhuman primates to hunt, then try to apply those pressures to understand the development of human hunting.

Outline

I. With data amassed on the evolutionary baseline represented by the great apes, biological anthropologists endeavor to model changes during the period of human evolution. Over the 50 years since Washburn first popularized this method, increasingly more complex models have appeared.

- **A.** Of all animals, it is the great apes with which humans share the most *homologies*, those characteristics arising from closely shared descent.
- **B.** The most balanced evolutionary models look not just at great ape-human similarities, or great ape-human differences, but at both. Thinking about one side without the other is unproductive.

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II. Some biological anthropologists construct *referential models*.

- **A.** In referential models, one "best fit" primate is taken as a referent, or "stand-in," for early humans. In Washburn's day, the species of choice was the East African baboon, based on its savanna adaptation.
- **B.** Chimpanzees are now the most popular choice for the "best fit" great ape, based on the complexity of their social bonds and cognition.
- **C.** The evolution of human hunting has been modeled referentially with provocative results. As we know, chimpanzees do hunt cooperatively in groups, and their behavior may shed light on how and why early humans began to hunt.

III. Other biological anthropologists prefer broader based models, referred to as *phylogenetic models*.

- **A.** These anthropologists say that it is misleading to rely so heavily on only one type of great ape. Referential models are likely to under-represent the differences between great apes and humans.
- **B.** Humans are equally as related to bonobos as they are to chimpanzees. No reason exists to "privilege" the chimpanzee over the bonobo in a referential model.
- **C.** None of the great apes besides chimpanzees hunts. There is no strong phylogenetic basis for modeling a specific pathway for the evolution of human hunting.

IV. A third group of biological anthropologists embraces conceptual models.

- **A.** As its name implies, a *conceptual model* focuses not on certain kinds of primates but on certain concepts and processes. These relate to evolution and how change may occur over time as primates respond to selection pressures.
- **B.** In conceptual models, all nonhuman primates showing the behavior(s) of interest, not just the great apes, are eligible to be included in the modeling process.
- **C.** In predicting aspects of the evolution of human hunting, then, a population of hunting monkeys is as revealing as a population of hunting chimpanzees. A classic example involves a model based in part on a group of Kenyan baboons that, for a time, hunted intensively.

V. The question, then, is not *whether* to use nonhuman primates as models but *how* to use them.

- **A.** Referential, phylogenetic, and conceptual models are critically important because the fossils and archaeological sites connected with early human evolution yield relatively few clues about behavior.
- **B.** The best models will yield predictions that can be tested by the fossil record of human evolution, a topic to which we turn in the next lecture.

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Essential Reading:

De Waal, *Tree of Origin,* chapter by Byrne.

Questions to Consider:

1. Can you think of objections that those who make referential or phylogenetic models might raise against the process of conceptual modeling?
2. Which of the three types of models do you find most persuasive for understanding the evolution of human hunting? Why?

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Lecture Nine

Introducing the Hominids

Scope: What is the relationship of the first human ancestors to the great apes? Where, and at what point in time, did the first human ancestors appear? How did these newly evolved primates differ from the great apes?

In seeking to answer these questions, we will introduce the hominids, the group of primates loosely considered to be human ancestors. (Some hominids, as we will see, are direct human ancestors, whereas others appear to be side branches.) The hominids evolved in Africa, at 6 or 7 million years ago. They diverged from a common ancestor with the African great apes, but the specific form of this ancestor is something of a mystery to biological anthropologists, because no fossils of it have yet been found. Using evolutionary theory and molecular anthropology, however, we can derive clues about the common ancestor.

We next explore some basic facts about how hominid fossils are discovered and named. We consider, in an introductory way, how these hominids differ anatomically from the great apes. A major distinction can be found in the locomotion system. Great apes are knuckle-walkers and brachiators that may walk erect for short distances but quickly tire when bipedal. By contrast, the earliest hominids are adapted for true upright walking. We consider a few of the many theories for why bipedalism may have evolved through natural selection.

Outline

I. Hominids include human ancestors, those that evolved directly into *Homo sapiens* and others, dating back to the time of divergence from the African great ape lineage.

- **A.** The hallmark of the hominids is bipedalism. More than any other factor, walking upright separates the early hominids from the great apes.
- **B.** The earliest hominids are all found in Africa.
- **C.** These early hominids did not evolve directly from the African great apes. Hominids and African great apes shared a common ancestor. The form of this common ancestor was likely quite generalized.

II. The timing of the hominid-great ape divergence from a common ancestor is hotly debated.

- **A.** As recently as 30 years ago, biological anthropologists thought that the oldest hominids were approximately 3 million years old.

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B. In recent decades, the date for the earliest hominids has essentially doubled; that is, we now have evidence for hominids dating back to 6 or 7 million years ago.

C. The divergence of hominids from great apes, then, logically must have occurred before about 6 or 7 million years ago.

D. Finding a fossil of the common ancestor of hominids and African great apes would help our understanding greatly, but no such fossil has yet been located.

E. Molecular anthropology provides an additional source of information about the common ancestor.

1. Comparison of molecules (proteins) across species tells us that orangutans speciated first, gorillas next, chimpanzees and bonobos next, and hominids, of course, last.
2. The timing of these speciation events can be estimated by constructing a molecular clock using rate of mutation in genetic material. A calibration date from the fossil record is imposed on the relative relationships already assessed. The result suggests that the common ancestor of hominids, chimpanzees, and bonobos lived at around 6 or 7 million years ago.
3. Not all biological anthropologists accept the molecular clock. Some say its method is flawed. They point out that as the timing for the earliest hominids is pushed back closer and closer to 7 million years, the speciation date derived by the clock seems more and more unlikely.

III. Unlike the situation with the common ancestor, scientists have uncovered fascinating bits of information about the very earliest hominids. Interdisciplinary research teams must work out whether or how their finds fit into existing "family tree" schemes of hominids.

A. "Fossil hunters" go to Africa in interdisciplinary teams to scour likely sites for skeletal remains of the earliest human ancestors. Biological anthropologists are key members of such teams.

B. Deciding whether skeletal material uncovered represents another individual in an already known species or is different enough to warrant naming a new species is tricky business for researchers.

1. Recall that two animals can be designated as belonging to two different species only when they cannot interbreed and produce fertile offspring. This test is difficult to apply to fossils.
2. Scientists must choose a Latin scientific name for their specimens—whether an existing name or a new one.
   a. The binomial Latin system indicates, as with the example *Homo sapiens*, genus first and species second. The name chosen conveys extra information, as well.

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   b. Great debates often break out when scientists name new hominid species, with others in the field lining up to agree or disagree.

IV. Most of the data about early hominids involve anatomical adaptations. As we have seen, bipedalism is the key hominid adaptation. Biological anthropologists offer a number of theories to explain why early hominids are so differently adapted, compared with great apes, in their locomotor system.

A. Natural selection operates from a starting point of the existing variation already present within a population. The fact that great apes—and thus, likely, the common ancestor—can walk bipedally for short distances is important.

B. Some anthropologists point to climate change as the key factor leading to evolution of habitual bipedalism.

C. Other anthropologists look instead at dietary selection pressures in the development of bipedalism.

D. As we will see in the next lecture, the modern bipedal gait probably evolved only gradually in hominids.

Essential Reading:

Jurmain et al., *Introduction to Physical Anthropology*, pp. 133–35 in chapter 5.

Marks, *What It Means to Be 98% Chimpanzee*, chapters 1 and 2.

Supplementary Reading:

Investigate the Internet site www.tamu.edu ("Anthropology in the News" at Texas A&M University) for recent updates on new hominid fossils or new interpretations about existing hominid fossils. Checking this site occasionally over the time period during which you listen to these lectures almost guarantees that you will discover vital new information on this topic.

Questions to Consider:

1. Why would it be unlikely (not impossible but unlikely) for the common ancestor of hominids and African apes to have already evolved bipedality?
2. Can you think of other possible selection pressures than the ones described here for the development of bipedality?

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Lecture Ten

Lucy and Company

Scope: Almost 30 years after its discovery in Ethiopia, one of the world's most well known hominid fossils still informs us about our early evolutionary history. In this lecture, we will focus on the hominid known as "Lucy," who lived approximately 3 million years ago, and on other hominids alive at the early period of human evolution.

"Lucy," better known to science as *Australopithecus afarensis*, was a short, apparently female, upright-walking hominid with a small, ape-sized brain. Uncovering a creature with this combination of traits stunned scientists, who had long theorized that brain-size increase occurred soon after the divergence between great apes and hominids. Lucy was proclaimed the oldest hominid, the one at the base of the ancestral family tree of humans.

The conclusion that Lucy and her kind were bipedal has stood the test of time. Debates begun in the mid-1970s still rage, however, about the specific form of her upright walking: Was her gait modern, like our own striding walk? No agreement has been reached on this issue.

Further surprises were in store for biological anthropologists. As it turns out, at 3 million years old, Lucy was nowhere near the oldest hominid. The base of our family tree has been extended by more than 3 million years, as noted in the previous lecture. We can now see that even in our earliest evolution, multiple hominid forms coexisted—and they were bipedal from the first.

Outline

I. The year 1974 was a turning point for paleoanthropology; in this year, "Lucy" was found.

- **A.** The anthropologist Don Johanson went to Hadar, Ethiopia, in 1973 to search for hominid fossils. He found a bipedal knee dated to 3 million years ago.
- **B.** Returning the following year, Johanson made a stunning find of a 40% complete skeleton, also of a bipedal creature. The skeleton, nicknamed "Lucy," dated to 3.2 million years.
- **C.** The two Hadar discoveries rocked the paleoanthropology world, because until then, scientists had fully expected to discover that large brains had evolved before upright walking in the hominid line. Yet Lucy had an ape-sized brain.
- **D.** Johanson and his team named their fossil *Australopithecus afarensis* and described her anatomy as fully as possible.
  1. Johanson described many of Lucy's traits as "intermediate" between apes and humans. Her teeth are a good example.
  2. It is a misunderstanding to conclude from this intermediate status that Lucy is a "missing link" of evolution. Because humans did not evolve from apes, there is no missing link.

II. Other examples of *Australopithecus afarensis* were found in East Africa, also showing bipedalism. Yet scholars began to debate, and still do debate, whether this bipedalism could have been modern in form.

- **A.** We now have more than 350 fossils, representing probably about 100 individuals, assigned to the species *Australopithecus afarensis.* This species lived from about 3.6 to 3 million years ago.
- **B.** Johanson and his team are adamant: Though the anatomy of this species was in some ways ape-like, its bipedalism was advanced and obligatory. That is, Lucy and her kind had evolved so far in the bipedal direction, especially in the pelvis, that they were obligated to move as fully bipedal creatures.
- **C.** Opponents of the idea of 3-million-year-old bipedalism insist that Lucy's intermediate anatomy precluded modern bipedalism. They analyze not only Lucy's pelvis but her legs and arms as well, concluding that *A. afarensis* was well adapted for tree-climbing.
- **D.** Few conclusions can be reached about the social behavior of *A. afarensis*; this species is a key candidate for nonhuman-primate behavioral models, whether referential, phylogenetic, or conceptual.

III. Lucy remains a classic find in paleoanthropology but has been dethroned as the oldest hominid on record.

- **A.** As of this writing, the earliest hominid appears to be a species called *Sahelanthropus tchadensis* that lived in Chad at about 7 million years ago. Both the antiquity and the location of this fossil have surprised paleoanthropologists, as does its unusual mix of anatomical traits.
- **B.** Before the announcement in 2002 of the discovery of *Sahelanthropus*, another hominid called *Orrorin tugenensis* (nicknamed "Millennium Man" for the year in which it was discovered) was thought to represent the oldest hominid. Although little technical analysis has yet been published about this hominid, researchers say that Millennium Man's legbones indicate definite bipedality.

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IV. Other species, too, existed before or along with *Australopithecus afarensis.* Rather than learning technical details of each hominid's anatomy, we will describe some examples. The main "take-home" point is that even very early after hominid divergence from the common ancestor, different hominid species coexisted.

A. Maeve Leakey has been instrumental in uncovering previously unknown hominid species. An example is a second early species in the genus *Australopithecus.* Dubbed *Australopithecus anamensis*, this hominid lived in Kenya at 4.2 million years ago.

B. Most stunning of Leakey's findings is a species, again from Kenya, that actually coexisted with Lucy. It looked different enough to be assigned a wholly new genus; it is termed *Kenyathropus platyops* (the "flat-faced" hominid).

C. This recent flowering of hominid discoveries presents challenges for scientists, as well as for new students of biological anthropology. Our picture of the hominid family tree is changing. We now know that human evolution did not occur in a linear fashion, with one species succeeding another. The emerging picture is much more complex.

D. Coexisting species played a major part in the story of human evolution after Lucy's time, as well. It is to this next phase and its cultural advancements that we turn in Lecture Eleven.

Essential Reading:

Johanson and Edey, *Lucy.* (Please read annotation in bibliography first.)

Supplementary Reading:

Visit www.zstarr.com/iho/ ("Institute of Human Origins" run by Don Johanson) for the latest information on this research team's always exciting work.

Johanson, *In Search of Human Origins* (video), 1994, PBS Nova Series. Part I is especially recommended for its stunning visuals of Hadar and Lucy.

Questions to Consider:

1. What are two aspects of *Australopithecus afarensis* that were unexpected by scientists at the time of its discovery?
2. In what significant ways has the human family tree been redrawn in the last decade or so?

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Lecture Eleven

Stones and Bones

Scope: Fifty years before Lucy's discovery, the first australopithecine was found in South Africa. Dated to more than 2 million years ago, that hominid, we now know, comes from one of the two major lineages that coexisted in the time period after Lucy's existence. We can contrast the anatomy of these two lineages, but they have left behind virtually no cultural traces.

At about 2.5 million years ago, a revolutionary new ability appeared on the hominid scene. For the first time, with the larger-brained *Homo habilis*, hominids began to modify stone tools. The process sounds simple to us today. One rock was bashed against another to produce two tools: a larger core and a smaller sharp flake. The tools could then be used in efficient food-gathering. Here was a behavior that, to our knowledge, no chimpanzee or earlier hominid had ever accomplished.

Was tool-making associated with other advances in hominid lifestyles? An early, influential model of *Homo habilis* lifestyle suggested that many modern human behaviors, including sharing food and living in semi-permanent base camps, had already evolved by 2 million years ago. Newer models are more cautious but agree that *Homo habilis* was an innovator: These hominids processed animal carcasses and, in so doing, transported both animal bones and Oldowan stone tools around the landscape. This planning behavior points to an intelligence that reflects the increased brain size of the *Homo* genus.

Outline

I. Exactly 50 years before Lucy's discovery, the South African anatomist Raymond Dart uncovered the very first fossil to be categorized as an australopithecine.

A. The year 1924 was another watershed—as was 1974—for paleoanthropology. Finding a skull embedded in rock matrix, Dart came to realize that he was holding an ancient human ancestor.

1. Dart knew immediately from the skull's anatomy that this individual had walked bipedally.
2. He named the individual *Australopithecus africanus.*

B. *Australopithecus africanus* is an example of a *gracile hominid.* Gracile species are those that are relatively slender and light-boned, without any major skeletal specializations.

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II. Other early hominids in the very same genus of *Australopithecus* are differently adapted in the skeleton and skull; they are referred to as *robust hominids* to set them apart from the gracile ones.

A. Examples of robust hominids are *Australopithecus robustus* in South Africa and *Australopithecus boisei* in East Africa.

B. These hominids, as their name implies, are heavier and heavier-boned. The main difference between robust and gracile species lies in the dentition, however, and in associated features of the skull.

C. Two lines of evidence suggest that robust hominids ate tougher, harder foods than did gracile hominids.

1. Skeletal and muscular differences point to a dietary divergence.
2. Comparative microscopic evaluation of the teeth results in an identical conclusion.

D. The robust forms went extinct at about a million years ago, perhaps because of overspecialization. During their long reign, they coexisted not only with *Australopithecus africanus* but with a new gracile form, *Homo habilis*, that appeared at around 2.4 million years ago.

III. With *Homo habilis*, paleoanthropologists see a major advance in the area of behavior: Modified stone tools are associated with this species.

A. The Leakeys, a famous paleoanthropology family, discovered a new, more advanced gracile hominid living at the site of Olduvai Gorge, Tanzania.

B. Recognizing the new hominid's enlarged brain size and its association with modified stone tools, Louis Leakey named the find "Handy Man" or *Homo habilis.*

C. The inventor of the Oldowan tools may or may not be *Homo habilis.* The very first examples of modified tools predate the earliest *Homo habilis*, leaving researchers with an unsolved mystery.

D. The stone tools, named Oldowan, represent fairly simple technology in that one rock was used to strike flakes off another rock. Two tools, the core and the flake, result.

E. Oldowan tools were likely all-purpose in nature. They probably aided *Homo habilis* in various aspects of foraging, ranging from meat to plant processing.

IV. Beyond Oldowan tool manufacture, how modern-like were groups of *Homo habilis*? This question has been a point of contention for 25 years.

A. The archaeologist Glyn Isaac published a highly influential model of *Homo habilis* behavior in 1978.

1. Isaac saw in archaeological sites of 2-million-year-old *Homo habilis* evidence for food-sharing and semi-permanent base camps.
2. He interpreted this hominid as being fundamentally humanlike in many of its behavioral adaptations, relying heavily on modern forager peoples to flesh out his inferences.

B. Other archaeologists, notably Richard Potts, challenged Isaac's formulation.

1. Potts was skeptical that the gracile, relatively defenseless *Homo habilis* would have shared food at base camps. He pointed out that many dangerous African predators, for example, the big cats, would have competed with these hominids for meat.
2. Potts offers an alternative "tool cache" interpretation of the archaeological material found at *Homo habilis* sites. In this model, Oldowan tools were strategically placed by hominids around the landscape for food processing. No food-sharing or base camps were evident, however.

C. Without a doubt, despite the controversy about its humanlike status, *Homo habilis* is responsible for some new cultural behaviors on the hominid scene. These individuals processed animal bones and brought together the animal bones and modified stone tools in new ways. The enlarged hominid brain likely played a role in these innovations.

Essential Reading:

Jurmain et al., *Introduction to Physical Anthropology*, chapters 9 and 10.

Supplementary Reading:

Potts, *Early Hominid Activities at Olduvai.*

Questions to Consider:

1. Discuss how natural selection (and different selection pressures) might help explain the significant anatomical differences between gracile and robust australopithecines.
2. Which model of *Homo habilis* behavior, Isaac's or Potts's, do you find more convincing? Why?

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Lecture Twelve

Out of Africa

Scope: The human lineage clearly originated in Africa, and all the hominids we have considered so far were confined to that continent. Shortly after 2 million years ago, however, a new hominid evolved and almost immediately migrated out of Africa. *Homo erectus* was a wanderer right from the beginning. In fact, *Homo erectus* is considered by many anthropologists to represent a major shift point in human evolution in several ways.

The tools used by *Homo erectus* are more varied and more efficient than are the Oldowan tools. The hand ax is a good example of a tool that makes its appearance at this point in human evolution. Evidence from China and elsewhere also suggests that *Homo erectus* probably was able to control fire, an ability that would have significantly enhanced this hominid's survival in major ways.

Because of its bi-continental distribution, *Homo erectus* is a good test case for the claim that natural selection shaped hominid adaptation. Do *Homo erectus* fossils in Africa look significantly different than those in Asia? In some ways, yes, as the wonderfully complete "Nariokotome Boy" skeleton tells us. This fossil, found in Kenya, shows that a 12-year-old boy was extremely well adapted to tropical conditions. Some biological anthropologists even suggest that such differences are enough to place African *Homo erectus* in a different species than its Asian counterparts, but recent evidence strengthens the case for a single-species interpretation.

Outline

I. As we have seen, the situation in early human evolution is both confused and confusing. Before moving forward, we will review some of the major conclusions of the time period between 7 and 2 million years ago.

- **A.** All early hominids were bipedal and lived entirely in Africa; they were concentrated in East and South Africa.
- **B.** Designation of the "oldest hominid" keeps shifting, but we know for a certainty that multiple forms coexisted even very early.
- **C.** It is debatable which of several early forms gave rise to the first hominid in our own genus, *Homo habilis*. A gracile hominid, rather than a more specialized robust one, is a likely candidate.
- **D.** Behaviorally, significant advances were reached at about 2.5 million years ago. Animal carcasses were processed at this time by *Homo habilis* using modified stone tools.

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II. Perhaps the single most critical shift in human evolution occurred with the hominid that first appeared at 1.9 million years ago. *Homo erectus*, possibly a descendant of *Homo habilis*, has been known to science since the late nineteenth century. More and more details of its behavior are emerging from recent paleoanthropological inquiry.

- **A.** *Homo erectus*, discovered by Eugene Dubois on the island of Java, is the first hominid species to live on two continents: Asia and Africa. (Some biological anthropologists even claim that a few early European fossil forms are from *Homo erectus*, but this assertion is highly controversial.)
- **B.** A recent surprise is that *Homo erectus* reached Asia very early in its time period—by about 1.8 million years ago. This is a much earlier migration than earlier realized, thanks to great scientific improvements since Dubois's day.
- **C.** Putting together information from Africa and Asia, we can point to major innovations in the behavior of *Homo erectus* compared with that of *Homo habilis.*
  1. The *Homo erectus* toolkit is more advanced and more varied than were Oldown tools. The staple tool was a biface, a core worked on both sides. The hand ax is a good example.
  2. *Homo erectus* almost certainly ate more meat than did earlier hominids. As we will discuss later (in Lecture Fourteen), it probably survived by increasingly efficient scavenging rather than regular hunting.
  3. Judging by evidence in such sites as Zhoukoudian, China, *Homo erectus* may have controlled fire. This behavioral adaptation would have allowed for advances in cooking, predation, defense, and temperature control.

III. How does the anatomy of *Homo erectus* underwrite or support the behavioral milestones just discussed? Do African and Asian forms of this hominid differ anatomically?

- **A.** The single most complete *Homo erectus* skeleton yields a wealth of information about the anatomy of at least some individuals.
  1. Found in Kenya in 1984 (with excavation continuing into 1985), the so-called Nariokotome Boy died at about age 12. He stood 5 feet, 3 inches tall and would have been over 6 feet tall had he lived to adulthood.
  2. Like other *Homo erectus* individuals, this one had an enlarged brain compared to all earlier hominids.
  3. The best way to describe the Nariokotome Boy's adaptation is hypertropical. That is, his long, slender limbs and his generally elongated body were products of natural selection for living in the tropics.

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B. *Homo erectus* individuals living in Asia do differ somewhat; some scientists say the difference is pronounced enough to warrant a separate species designation, but we will not adopt this "splitter" taxonomy. There is no reason to suggest that the two forms would have been prevented from interbreeding had they met.

IV. Though *Homo erectus* did overlap with other hominid forms, it seems likely that all its behavioral advances allowed it to outcompete other hominids. It seems clear (at least for now!) that *Homo erectus* is a direct ancestor of *Homo sapiens.*

Essential Reading:

Jurmain et al., *Introduction to Physical Anthropology*, chapter 11.

Questions to Consider:

1. Discuss both biological and cultural ways in which *Homo erectus* represents a critical shift point in human evolution.
2. What role do you think is played by unusually complete hominid fossils, such as the Nariokotome Boy and Lucy, in informing those people who are reluctant to accept that humans have evolved?

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Timeline

Prehistory

(**Note**: Biological anthropologists frequently revise these dates, updating them according to new information. Included here are the current best estimates. The abbreviation *mya* stands for "million years ago.")

70 mya	Age of Dinosaurs nears an end; no primates yet exist
65 mya	Age of Mammals begins; ancestral primates appear
55 mya	Earliest definite primate
55–6 mya	Numerous speciation events produce ancestors to today's prosimians, monkeys, and apes
8–7 mya	Common ancestor to African apes and hominids
approx. 7 mya	First hominid, perhaps *Sahelanthropus tchadensis*
4.2 mya	First australopithecines
3.2 mya	Time at which "Lucy" lived (*Australopithecus afarensis*)
2.5 mya	First hominid-modified stone tools
2.4 mya	First hominid in the *Homo* genus, *Homo habilis*
1.9 mya	First *Homo erectus*, in Africa
1.8 mya	Some populations of *Homo erectus* migrate out of Africa to Asia
130,000	First Neandertals
125,000	First *Homo sapiens*
30,000	Disappearance of Neandertals; *Homo sapiens* is the only surviving hominid

History

1856	First Neandertal discovery, in Germany
1859	Charles Darwin publishes *On the Origin of Species*

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1891 ..... First *Homo erectus* discovery, in Java

1924 ..... Raymond Dart finds first australopithecine, in South Africa

1925 ..... Scopes Monkey Trial in Tennessee

1951 ..... Sherwood Washburn outlines the new physical anthropology

1960 ..... Jane Goodall begins observations of wild chimpanzees

1968 ..... Washburn and Lancaster publish "Man the Hunter" paper

1974 ..... Don Johanson uncovers "Lucy" in Ethiopia

1978 ..... Glyn Isaac publishes theory on *Homo habilis* behavior

1984-1985 ..... Discovery of "Nariokotome Boy" (*Homo erectus*) in Kenya

1990s ..... Excavation of African sites showing that early modern behavior did not originate exclusively in Europe

2002 ..... Announcement of the fossil discovery *Sahelanthropus tchadensis* from Chad, currently considered the oldest hominid known to science

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Glossary

(**Note**: For names of specific primates, please refer to the Species Sketches section.)

Acclimatization: A physiological process of adaptation, as to extreme climate, in either the short or long term.

Adaptive radiation: Rapid expansion of new animal forms into new habitats.

Anthropoids: One of the two major groupings of primates; the anthropoids are diverse, including all the monkeys, apes, extinct human ancestors, and modern humans.

Apes: A subset of anthropoids that tends to be large-bodied and includes humans' closest living relatives.

Biological anthropology: The subfield of anthropology that takes as its subject matter the evolution, genetics, and anatomy of, and modern variation within, the human species.

Conceptual model: Model that focuses on evolutionary processes rather than specific organisms in trying to understand the behavior of extinct human ancestors.

Differential reproductive success: Refers to the fact that within a population, some individuals will produce more healthy offspring than others.

Evolution: Change in the genetic structure of a population.

Gene: A sequence of DNA that can be passed on to offspring.

Gene flow: One of the major mechanisms of evolution; refers to the exchange of genes between populations.

Gene pool: All the genes shared by members of a single population.

Genetic drift: One of the major mechanisms of evolution; occurs in small populations when random events shift the composition of the gene pool.

Gracile: Relatively light-boned and slender.

Hominids: Primates, including those that led to modern humans, characterized by bipedalism; evolved after the evolutionary split with the great apes.

Homology: A similarity based on shared descent (if two primates have homologous traits, the traits are alike owing to a common evolutionary heritage).

Iconic gesture: Gesture that indicates the specific action that the gesturer wishes another animal or person to take.

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Intelligent design: A set of beliefs predicated on the idea that some organs and organisms, such as humans, are so complex that they could have arisen only by design (not by unguided evolutionary mechanisms).

Matriline: A group of related females.

Mitochondrial DNA (mtDNA): Inherited only through the maternal line and, thus, changed only via mutation, mtDNA is a possible tool for tracing descent lines in prehistory.

Monkeys: A diverse set of anthropoids that are relatively small-bodied, more distantly related to humans than are the apes.

Multiregional model: One of two major models for the origins of modern humans; this one suggests that *Homo sapiens* evolved from earlier hominids on three continents at about the same time in response to regional selection pressures.

Mutation: One of the major mechanisms of evolution; refers to a change in the structure of DNA within a gene.

Natural selection: The single most important mechanism of evolution; refers to the fact that some individuals within any population will be better adapted to their local environment than others, leading to greater reproductive success.

Out-of-Africa replacement model: One of two major models for the origins of modern humans; this one suggests that *Homo sapiens* evolved first in Africa, then spread out to other areas and replaced all other hominids.

Patriline: A group of related males.

Phylogenetic model: Model that proposes taking into account the behavior of all four great apes in trying to understand an extinct human ancestor.

Population: Members of a species that share a common gene pool and mate more with one another than with members of other populations.

Primates: Division of mammals that includes all prosimians, monkeys, apes, extinct human ancestors, and modern humans.

Prosimians: One of the two major groupings of primates; the prosimians evolved first and are relatively specialized.

Punctuated equilibrium: The idea that evolution may sometimes proceed in rapid leaps rather than always by small, gradual modifications.

Race: A term used to suggest that humans can be sorted into distinct groups based on genetic traits, such as skin color or nose shape. Almost all biological anthropologists agree that this term has no biological validity.

Referential model: Model that proposes a 1:1 relationship between the behavior of some living primate and an extinct human ancestor.

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Robust: Heavy-boned and strong.

Scientific creationism: A set of beliefs predicated on the ideas that the Earth is young and humans were created by a supernatural force within the last 10,000 years.

Sexual dimorphism: Anatomical differences based on one's sex.

Speciation: The process by which new species are formed from existing ones.

Species: A grouping of organisms whose members can all interbreed with one another and produce fertile offspring. The species is a larger grouping than the population.

Theory: In science, a set of principles that has been supported by observation and testing.

Theory of mind: The ability to take into account the mental perspective of another.

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Species Sketches

Australopithecus afarensis: A gracile hominid species that includes "Lucy" and lived in Africa from about 3.6 to 3 million years ago.

Australopithecus africanus: The first australopithecine to be discovered, this gracile African form lived from perhaps 3.6 to about 2 million years ago.

Australopithecus anamensis: An African hominid dating to about 4.2 million years ago.

Australopithecus robustus and ***Australopithecus boisei***: Two robust hominids that lived in Africa along with gracile forms but eventually went extinct, apparently due to dietary overspecialization.

Bonobo: One of the African great apes; lives in bisexual communities with greater emphasis on female-female bonds than is found in the chimpanzees.

Chimpanzee: One of the African great apes; lives in bisexual communities with greater emphasis on male dominance than is found in the bonobos.

Gelada baboon: An Old World monkey that lives in one-male units; females bond with one another to prevent domination by males.

Gorilla: One of the African great apes; lives in either one- or two-male groups.

Great apes: Humans' closest living relatives, these large-bodied and large-brained apes are the orangutan, gorilla, chimpanzee, and bonobo.

Hamadyras baboon: An Old World monkey that lives in one-male units; males dominate females, harassing and biting them.

Homo erectus: The first hominid to live in Asia as well as Africa, this species, which includes the "Nariokotome Boy," is thought of as a turning point in human evolution. Appearing at about 1.9 million years ago, its "endpoint" is hotly debated but may be about 400,000 years ago.

Homo habilis: The first hominid in our own genus, this species is famous for being the first (as far as we know!) to manufacture stone tools. It lived in Africa from about 2.4 to 1.9 million years ago.

Homo neandertalensis: See **Neandertal**, below.

Homo sapiens: Modern humans; us. Modern human anatomy developed at perhaps 125,000 to 100,000 years ago.

Kenyanthropus platyops: Flat-faced hominid of Kenya, discovered by Maeve Leakey, that existed at about 3.5 million years ago. This species thus overlapped in time with *Australopithecus afarensis*.

Lesser apes: Small-bodied apes of Asia, including gibbons, that usually live in monogamous pairs.

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Marmoset: A small New World monkey that lives in extended family groups.

Muriqui: A relatively large New World monkey that lives in peaceable social groups largely devoid of relative ranking.

Neandertal: Hominid that is likely a separate species from modern humans but overlapped with them in time and place. The Neandertals lived in Asia and Europe from about 130,000 to 30,000 years ago.

Orangutan: The only Asian great ape and the least social of all apes.

Orrorin tugenensis: A very old African hominid, dated to about 5.8 million years ago; dethroned by *Sahelanthropus tchadensis* in 2002 as the "oldest known hominid."

Rhesus monkey: An Old World monkey organized into matrilines with great emphasis on dominance hierarchies.

Ring-tailed lemur: A group-living African prosimian in which females are routinely dominant to males.

Sahelanthropus tchadensis: Best current candidate for the oldest hominid, at about 7 million years ago; announced in 2002 by scientists working in Chad, central Africa.

Savanna baboon: An Old World monkey organized into matrilines and heavily dependent on dominance hierarchies.

Slow loris: A nocturnal Asian prosimian that is far more social than expected for such a primate.

Transitional hominid species: The catchall term we use to refer to those hominids that lived after ***Homo erectus*** but before ***Homo sapiens***, with a mix of *erectus-sapiens* traits. These hominids are found in Africa, Asia, and Europe.

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Johanson, Don, and Maitland Edey. *Lucy: The Beginnings of Humankind.* New York: Simon and Schuster, 1981. A fact-filled, enjoyable account of Lucy's discovery specifically and theories of human evolution generally, this book gives an excellent feel for what it is like to be a fossil hunter in Ethiopia. It must be read in the context of the course, however; some of its conclusions about Lucy's place in the human family tree have been overturned by newer information.

Jurmain, Robert, Harry Nelson, Lynn Kilgore, and Wenda Trevathan. *Introduction to Physical Anthropology,* 8th edition. Belmont, CA: Wadsworth Publishing, 2000. The text of choice for many biological anthropologists, this book provides vital background information on the topics covered in this course. It includes superb visuals (photographs, charts, diagrams). The chapters cited as essential reading at the end of each lecture are keyed to the 8th edition, but newer editions, when available, would be even better.

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Natural History, April 2002 issue. Two features in this issue explain in clear terms issues of relevance to this course. First is a series of short opinion pieces that together constitute a written debate between evolutionary theorists and intelligent design advocates. Second is the column by science writer Carl Zimmer on evolution of the eye.

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Weiner, Jonathan. *The Beak of the Finch: A Story of Evolution in Our Time.* New York: Knopf, 1994. Reviewers have noted that this Pulitzer-Prize-winning account reads like a thriller! It details research done by the Grants, a husband-and-wife team of biologists that has carried out modern-day evolutionary studies on the finch populations in the Galapagos Islands—the descendant birds of those studied by Charles Darwin.

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Supplementary Reading:

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